a single female only, from Arfak. It is represented now on Plate VII., and I am again much obliged to Dr. Gestro for giving me the opportunity of figuring the type in 'The Ibis.' Then there are *Æ. bennetti*, Salvad., and *Æ. wallacei*, Gray, both known from a number of specimens, and lastly *Æ. plumifera*, Rams. In the original description this species was compared with *Æ. bennetti*, but it seems much more closely allied to *Æ. rufescens*, or less probably *Æ. salvadorii*. Salvadori has also described an *Æ. loriæ* (Ann. Mus. Civ. Genova, xxix. p. 564), which I kept separate in the 'Catalogue of Birds,' xvi. p. 650. Dr. Gestro has now lent me the type, and I am sorry to say I cannot distinguish it in any way from the darker specimens of *Æ. bennetti* in the British Museum, though in the original description it has only been compared with *Æ. wallacei*, which is, of course, different.

P.S. *May 12th*.—During my recent visit to Paris, Dr. Oustalet kindly showed me his series of *Collocalia germani*, described in Bull. Soc. Philom. Paris, 1876, p. 1–3, and I found them to be the same as the form named *C. meryuiensis* (subspecies of *C. francica*) in the Cat. of Birds. Of course Oustalet's name has the priority by a long way. I also saw *Chætura cochinchinensis* of Oustalet. It is a very small form of *Chætura caudacuta nudipes*, having the tail square, and is not at all related to *C. gigantea*. Dr. Büttikofer has also kindly sent me a sketch of the tail of his *C. klaesii*, which is square. It is evidently the same bird. The species probably breeds somewhere in the north, and both the type-specimens were shot on migration.

XXXIV.—*On the Skull, Sternum, and Shoulder-Girdle of Æpyornis*. By Chas. W. Andrews, B.Sc., F.G.S., Assistant in the British Museum (Nat. Hist.).

(Plates VIII. & IX.)

A small collection of remains of the extinct birds of the genus *Æpyornis*, including portions of two skulls, two

imperfect mandibles, some coraco-scapulæ, a nearly perfect sternum, and some small bones which I regard as the rudimentary humeri, has recently been sent to England by Dr. Forsyth Major. All these specimens were obtained in Central Madagascar, and, although many of them leave much to be desired in the matter of completeness, a short description of them, with figures, may be welcome, since, except what can be gathered from the brief description of the skull, mandible, and shoulder-girdle of *Æ. mulleri* given by Milne-Edwards and Grandidier*, nothing is known of these important portions of the skeleton in any member of the genus. A somewhat more detailed account† by the same authors of the skull and skeleton of *Mullerornis* shows that it differs considerably from *Æpyornis*, and in many points approaches *Casuarius*. In some respects, however, *Æpyornis* also resembles *Casuarius*, a fact long ago pointed out by Milne-Edwards and Grandidier.

The Skull and Mandible (see Plate VIII.).

The collection includes two specimens of the cranial portion of the skull, both unfortunately somewhat imperfect, a large part of the united premaxillæ of another individual, and two imperfect mandibles. All these probably, the two crania certainly, belong to the same species, but what that species is cannot be determined. Dr. Major, on his labels, suggests that it may be *Æ. hildebrandti*, and very possibly he is right; but in view of the confusion that has arisen in the case of the Dinornithidæ, through the conjectural reference of isolated bones to the various species, it seems best to leave the specific name of these remains undetermined, until the discovery of associated sets of bones renders it possible to settle the question finally.

In the following account of the skull the terms employed

* "Observations sur les *Æpyornis* de Madagascar," Comptes Rendus Acad. Sci. t. cxviii. 1894, p. 122.

† "Sur des Ossements d'Oiseaux provenant des Terrains Récents de Madagascar," Bull. Mus. Hist. Nat. pt. i. (1895), p. 9.

by Prof. J. Parker in his paper on the Cranial Osteology of the Moas are used so far as possible.

As already stated by Milne-Edwards and Grandidier, the large occipital condyle, as in *Apteryx* and the Dinornithidæ, is strongly pedunculate; except that its upper surface is rather flattened, it is hemispherical in form, and in neither specimen is there any trace of a notochordal depression.

The *foramen magnum* (Plate VIII. fig. 2) is large and oval, its long (vertical) diameter measuring 17 mm., the short (horizontal) 12 mm. Its plane is somewhat inclined backward, but the upper margin only very slightly, if at all, overhangs the occipital condyle, owing to the great prominence of the latter. There is no trace of an occipital crest, but there is a very prominent supra-foraminal ridge, which is continued downwards to the inner angles of the paroccipital processes. Above the foramen the occipital surface slopes somewhat forwards; at first it is flattened, but above it passes by a gentle curve into the parietal region. The *lambdoidal ridges* are very feebly developed, if, indeed, the posterior may not be regarded as entirely wanting. The anterior, in its median portion, runs transversely in a straight line; laterally it turns downward, nearly joining the temporal ridge, and ventrally it becomes continuous with the outer border of the somewhat backwardly-directed paroccipital processes (*par.oc.*). These are very broad, and their evenly-curved ventral margin is about on a level with the bottom of the occipital condyle; their posterior surface is convex from above downward, while their anterior surface, forming the posterior wall of the tympanic cavity, is concave in the same direction.

The postorbital portion of the cranial roof (Plate VIII. figs. 1 & 3) is about equally convex from before backward and from side to side. Posteriorly it is narrowed by the encroachment of the deep temporal fossæ (*t.f.*), but in front of these it widens out and curves steeply downward, forming the large postorbital processes (*p.orb.pr.*). In the interorbital region the cranial roof is flattened and is somewhat narrowed. A most interesting point is the presence in the frontal region of numerous deep rounded pits (see Plate VIII. fig. 1). Of these

there are four main rows; the outer pair extend back on to the bases of the postorbital processes, while the inner terminate opposite the posterior margin of the orbit. In addition to these, there are a number of irregularly distributed depressions. The presence of these pits seems to indicate the former existence of a frontal crest of large feathers in the species to which these skulls belong, and it is a point worthy of note that, on the same grounds, Prof. Jeffery Parker has inferred the existence of a similar crest in certain species of Moa *.

The *basi-temporal platform* (Pl. VIII. fig. 2) is very much more prominent than in any of the Dinornithidæ, its nearly vertical posterior surface being about as deep as broad, while in the New Zealand birds the depth is always much less than the breadth. In the other Ratitæ, except *Casuarius*, the basi-temporal platform is only slightly raised above the general level of the floor of the skull, and the only bird in which it is more prominent than in *Æpyornis* appears to be *Aptornis*. The vertical basi-occipital surface has its ventro-lateral angles produced into stout mamillar tuberosities (*m.t.*) (in the figure that on the left has been restored), between which its inferior border is concave: immediately beneath the occipital condyle there is a hemispherical depression, the *precondylar fossa* (*p.c.f.*).

The ventral surface of the platform is remarkable for its extreme shortness from front to back, its length from the base of the rostrum to the mamillar tuberosities being rather less than its width at those processes. One of the consequences of this shortening is that the bases of the large basi-pterygoid processes are separated from the mammillar tuberosities by a shallow groove only. This is the ventral prolongation of the Eustachian groove, which is short and nearly vertical, and, as in the Dinornithidæ, remains open in the adult, although for a short distance near its lower end its edges come very near together. The posterior wall of the Eustachian groove is united to the inner angle of the paroccipital process by a narrow bridge of bone; between

* "On the Presence of a Crest of Feathers in certain Species of Moa," Trans. New Zealand Institute, vol. xxv. (1892) p. 3.

this and the side of the basi-temporal platform there is a funnel-shaped depression, at the bottom of which a foramen, probably that transmitting the internal carotid (*car.for.*), opens. Immediately above, and somewhat to the inner side, of this is the *vagus foramen* (x.). In the middle line, between the bases of the basi-pterygoid processes, there is a circular foramen, which seems to penetrate into the brain-case; this opening is the *anterior basi-cranial fontanelle*, occasionally present in *Dinornis*.

In both specimens the rostrum and the ends of the basi-pterygoid processes are broken away.

The tympanic cavity is shallower than in the Dinornithidæ, owing mainly to the fact that the inner angle of the par-occipital process is less prominent; on the other hand, the greater width of this process makes the cavity wider than in the New Zealand bird. The margin forms an even curve, much as in *Dinornis*. On the roof of the tympanic cavity, immediately internal to the zygomatic process, is the articular facet for the quadrate; the form of this articulation, and the share in its composition taken by the various bones, are shown in fig. 7 of Plate VIII. It is more circular in outline than in the other Struthious birds, and is very deeply concave. The various foramina opening into the tympanic cavity are arranged almost exactly as in the Dinornithidæ. The anterior tympanic recess and the pretemporal wings are very large. On the left side in the specimen figured the *columella auris* is still in place.

The temporal fossa (*t.f.*, fig. 3) is very deep and narrow, and its anterior and posterior borders are nearly parallel. On the upper surface of the skull the fossæ are widely separated one from another, the interval between them being about equal to the width of the interorbital region of the frontals. There is a large, nearly flat, posterior temporal fossa (*post.t.f.*), bounded internally by the inferior tympanic ridge, which is not produced into a pre-tympanic process, and externally by the post-temporal ridge, which forms the antero-external margin of the zygomatic process. The squamosal does not form a prominence as in the Dinornithidæ, but has a nearly

flat outer surface. The zygomatic process (*zyg.*) is very long, and is directed downward and forward, and, at its lower end, somewhat outward.

Unfortunately, the whole of the interorbital region in front of the optic foramen is much broken, but, so far as can be seen, it resembles that of *Dinornis*, the olfactory chambers having extended far back. The arrangement of the optic and other foramina in its neighbourhood is shown in fig. 8 of Plate VIII. It will be seen that the oculomotor (III.) and orbito-nasal (v.') apertures lie in a line immediately behind the optic foramen (II.). Immediately below the oculomotor foramen is the opening, in one case divided into two by a bar of bone, which transmits the internal ophthalmic artery and sixth nerve (VI. & *a*) : the foramen for the fourth nerve (IV.) is dorsal to the optic. Except that there is no distinct lacerate fossa, this arrangement is similar to that seen in some Moa skulls.

The whole of the rest of the skull is wanting, with the exception of the premaxillary region (fig. 4), and of this the anterior extremity is lost, so that the exact form of the beak cannot be determined. The maxillary and palatine processes together form on either side a thin plate of bone, with a slightly grooved alveolar border. The anchylosed facial processes, constituting a stout bar, rise rapidly from the body of the bone, which is hollowed out posteriorly by a very deep fossa, bounded by the bases of the facial and maxillary processes.

In the mandible (Plate VIII. figs. 5 & 6) the articular surface for the quadrate is very deep, but is proportionately smaller than in the other Ratites; large internal (*i.a.p.*) and posterior angular (*p.a.p.*) processes are present, the upper surface of the former bearing a pneumatic foramen; there is also a prominent inferior angular process (fig. 6, *inf.a.p.*). Looked at from above, the articular region closely resembles that of the mandible of *Casuarius*. The mandibular rami are very massive and straight; the dorsal edge bears a prominent coronoid process, in front of which it widens out, so that its anterior half forms a grooved

alveolar surface about 10 mm. wide, narrowing towards the anterior end. The outer surface of each mandibular ramus is deeply grooved for about its middle third.

The dimensions of the skull and mandible are :—

	mm.
Length of *basis cranii*	36
Width at paroccipital processes	76
Width at squamosal	76
Greatest width at temporal fossa	60
Least width between temporal ridges	60
Width at postorbital processes	86
Height of cranium (approx.)	65
Distance between optic foramina	9
Length of mandible (approx.)	170
Width of articular end	29

The incompleteness of the specimens here described renders detailed comparison with the skull of the other Ratitæ impossible at present, since many of the most important characters are to be found in the palatal and facial regions, which are entirely wanting in these fossils. Nevertheless, it will be seen that in several respects *Æpyornis* approaches the Dinornithidæ in the structure of its skull. Among the points of resemblance are the pedunculate occipital condyle, the prominent basi-temporal platform, the open Eustachian groove, the structure of the facet for the quadrate, and the presence of a frontal crest of large feathers (as in some of the Dinornithidæ).

The Sternum (Plate IX. figs. 1 & 2).

A nearly complete specimen of the sternum, in which only a portion of the antero-external region on the right side is wanting*, shows that this bone was truly "ratite," and was of a very remarkable and characteristic shape. Its most striking peculiarity is its extreme shortness compared with its width, its length in the middle line being only about a fifth of its width at the antero-lateral processes. At first sight it may appear that this shortening is due to the breaking away of some of the thin posterior region, but

* This fragment has since been found, so that the sternum is now complete.

closer examination shows that this is almost certainly not so. In the first place, the two halves of the posterior border are symmetrical, which would hardly be the case if the outline was the result of accidental fractures. Moreover, for about 25 mm. in the middle line the hinder border forms a gently concave curve, with a sharp clean edge, clearly the natural margin of the bone; on either side of this the edge is truncate, and in life was evidently bordered with cartilage, the extent and form of which it is, of course, impossible to determine.

The anterior edge of the sternum is thin and sharp. Its middle portion, between the coracoid grooves, is deeply concave; on either side, where it forms the upper lip of these grooves, it is convex, and externally it passes into the base of the very prominent and stout antero-lateral processes (*ant.lat.pr.*). The coracoid grooves are about 60 mm. long, and are separated by an interval of 66 mm. The middle portion of their lower lip forms a very prominent plate of thin bone, about 14 mm. high and 25 wide.

The lateral border is formed in front by the antero-lateral processes, in the middle by a thickened area, bearing four facets for the articulation of the sternal ribs, while posteriorly it becomes a comparatively thin edge, which passes into the hinder border in the rounded postero-lateral angle. The first of the costal processes is the most prominent; it rises at the base of the antero-lateral process, above the level of which it lies. On its anterior surface there is a large pneumatic foramen. The articular surface is obliquely elongated, and slopes downward and backward. The next two processes are similar in form, and are separated from the first and from each other by deep pits. The fourth stands some distance behind the others, and its articular surface is nearly circular.

The form of the hinder border is shown in fig. 1, and the structure of its edges has already been referred to.

The body of the bone is for the greater part very thin, but in the middle line it is somewhat thickened, the visceral surface being raised in a broad transverse ridge, which dies away as it is traced towards the costal borders.

The dimensions (in millimetres) of the sternum are:—

	mm.
Length in middle line	47
Width between tips of antero-lateral processes about	235
Width between tips of postero-lateral processes about	280
Length of lateral borders (between end of antero- and postero-lateral processes)	125
Distance between inner end of coracoid grooves	66
Length of coracoid groove	60

It may be remarked that the right half of the specimen (left in the figure) has been much flattened, so that the measurements of the width, both at the anterior and posterior ends, as given above, are somewhat too great, and the same distortion is the cause of the want of symmetry seen in the figure.

Comparison of the sterna of *Struthio*, *Rhea*, *Dromæus*, and *Casuarius* with the fossil shows that they differ from it in almost every structural feature, as well as in the relative proportions of their length and breadth. In *Rhea*, however, the coracoids are separated from each other by a considerable interval, though a much smaller one than in *Æpyornis*, and the border between them is concave; in *Casuarius* and *Dromæus* there are four rib-facets.

The sterna of the New Zealand Ratitæ show a much greater resemblance to that of *Æpyornis*, although the various forms occurring among the Dinornithidæ are still very different, particularly in the straight or convex anterior border, the position of the pneumatic foramina, the absence or very rudimentary condition of the coracoid impressions, and the greater development of the xiphisternal region. On the other hand, the distance of the coracoid impressions from one another, and, in *Pachyornis*, the posterior divergence of the lateral borders and the great width in proportion to the length, are points of similarity.

It is in the sternum of *Apteryx*, however, as Milne-

Edwards and Grandidier have already stated*, that we find by far the closest resemblance to *Æpyornis*. The two agree in the deeply concave anterior border, the widely separated and similarly situated coracoid grooves, their great relative width, and the presence of four costal facets. In the posterior region the likeness is not so great, but in *Apteryx* this portion of the sternum is very variable in form. Usually there are a pair of lateral processes and a somewhat shorter median one, but the latter may be divided by a median notch (as in some of the Dinornithidæ), or may, occasionally, be entirely wanting, in which case the resemblance to the fossil is very great. This latter condition is shown in the figure of the sternum of *A. oweni* given in Meyer's 'Abbildungen von Vogel-Skeletten,' pl. 54. In this case the lack of the median process probably results from ossification not having extended into that portion of the metasternal cartilage; in *Æpyornis*, on the other hand, this cartilage appears never to have been developed, for, as above mentioned, the middle of the posterior edge of the sternum for about $2\frac{1}{2}$ cm. is thin and sharp, and clearly was not bordered by cartilage, although a fringe of that substance extended on either side along the rest of the hinder margin. If, therefore, as seems probable, the metasternal region is wanting, the sternum of *Æpyornis* consists of the two primitive costo-sternal elements only, and in this respect corresponds to an embryonic stage in the development of the sternum in the recent Ratitæ†.

The sternum of an embryo of *Apteryx australis* figured by Prof. Jeffery Parker on pl. xvi. fig. 218 of his memoir "On the Structure and Development of the *Apteryx*" (Phil. Trans. vol. 182 (1891) B) shows this condition, the metasternal region being still entirely absent; and if ossification had taken place at this stage without the further addition of cartilage, the resulting sternum would be almost exactly equivalent to

* "Observations sur les *Æpyornis* de Madagascar," Comptes Rendus Acad. Sci. vol. cxviii. (1894) p. 125.

† See Lindsay, "On the Avian Sternum," Proc. Zool. Soc. 1885, p. 711.

the present specimen. In this latter ossification probably took place from a pair of centres, the pleurostea (mesosterna), which gradually extended towards the middle line, where traces of their union are still visible (*s*, Pl. IX. fig. 1). The antero-lateral process, however, may, as in *Rhea*, have ossified from a second pair of centres (proostea).

From the foregoing description it will be gathered that in *Æpyornis* the sternum has undergone greater reduction than in perhaps any other bird, and that to some extent, in its similarity to the sternum of the New Zealand Ratitæ, it supports the conclusions derived from the cranium.

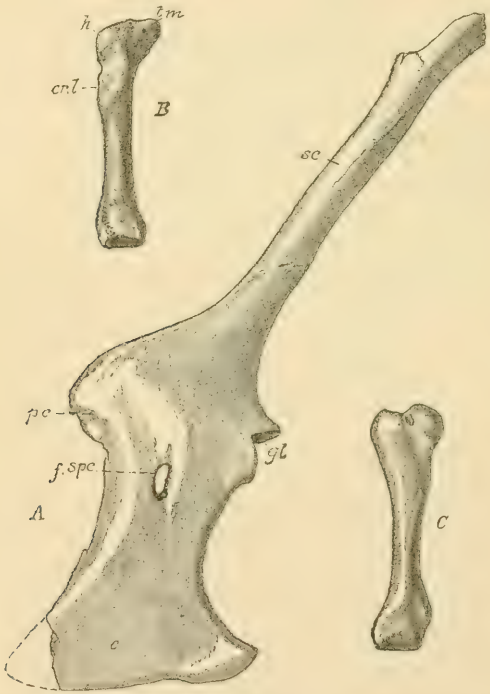


Fig. A, left coraco-scapula of *Æpyornis*; Figs. B & C, supposed humeri. ($\frac{1}{2}$ natural size.)

sc., scapula; *c.*, coracoid; *pc.*, precoracoid process; *f.spc.*, supra-coracoid foramen; *gl.*, glenoid cavity; *h.*, head; *t.m.*, *tuberculum mediale* (inner trochanter); *cr.l.*, *crista lateralis* (pectoral crest).

The Shoulder-Girdle.

The coraco-scapula (fig. A, p. 386) is typically Struthious in form. The scapula (*sc.*) is fused, and makes an obtuse angle with the broad coraco-precoracoid. This latter has a long sternal border, above which it is narrowed, both its inner and outer borders being concave. Near the middle of the narrowest part is the large supra-coracoid foramen (*f.spc.*); the bar of bone internal to this is probably a remnant of the middle portion of the reduced precoracoid, the upper end of which forms a prominent precoracoid process (*pc.*). The outer face of the combined bones is smooth, there being no trace either of the acro-coracoid process or of the coraco-scapular protuberance. The curved scapula (*sc.*) is long and slender; in the specimen figured the upper end is lost, but other examples show that it was flattened and slightly expanded. The coraco-scapular angle is about 140°. The glenoid cavity (*gl.*) is small, measuring 15 mm. in its long (vertical) axis, 11 mm. in the short; the coracoid and scapula take equal shares in its composition.

It will be seen that this coraco-scapula differs widely from that of *Struthio*, in which the precoracoid is a well-defined element; on the other hand, it is much less reduced than in the Dinornithidæ, in some of which, indeed, it is entirely wanting. In *Rhea* the coraco-scapula is also very different, but in *Casuarius* and *Dromæus*, particularly the former, the similarity to the fossil is greater, a circumstance that gives support to Milne-Edwards and Grandidier's opinion that *Casuarius* is a near ally of *Æpyornis*. *Apteryx* is also similar in some respects, but the position of the supra-coracoid foramen is different.

The dimensions of coraco-scapula are :—

	mm.
Length of sternal border (approx.)	65
Distance from middle of glenoid cavity to lateral sternal angle	60
Width of opposite supra-coracoid foramen	28

Humerus.

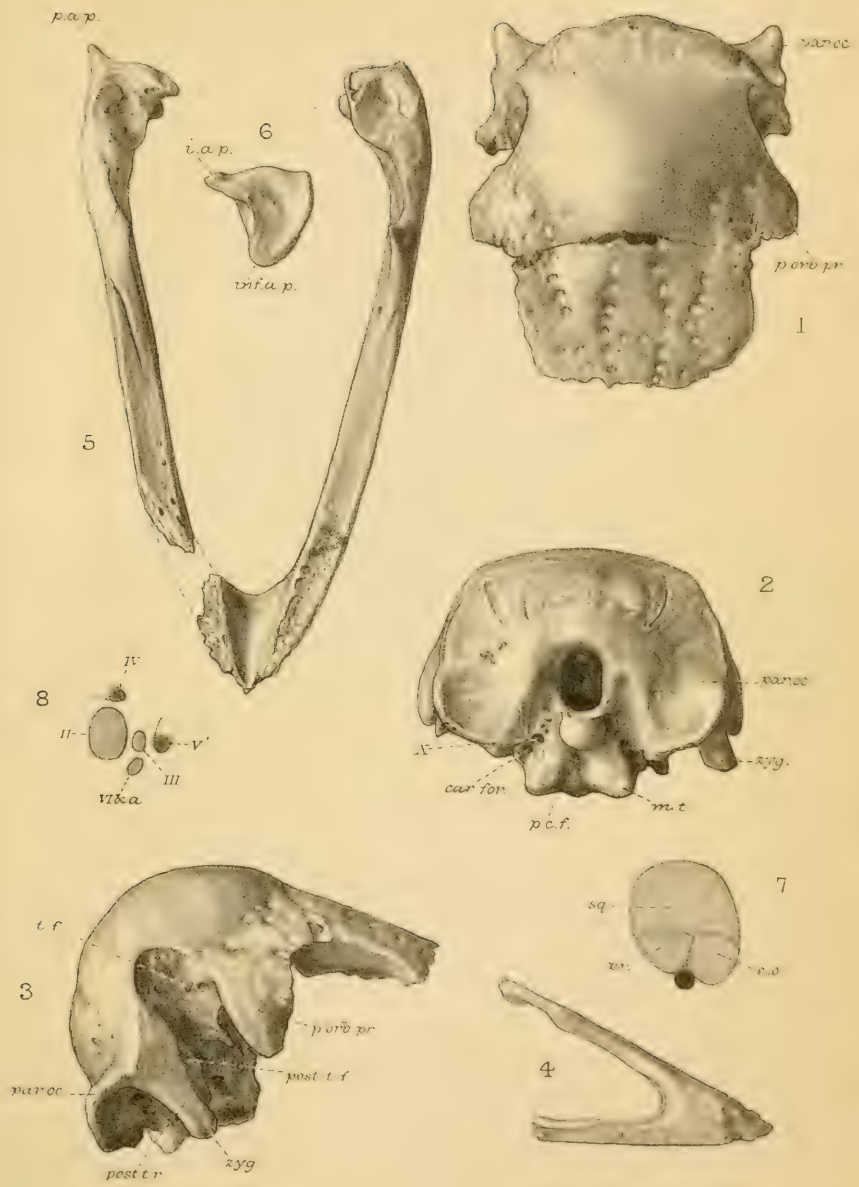
In the collection there are several small bones which I believe are rudimentary humeri of *Æpyornis*, though some of the specimens are so different from other avian humeri that it is by no means certain that this interpretation is correct. In the case of the bone shown in fig. B (p. 386), however, there seems to be no doubt that it is a much reduced humerus of a bird, presumably one of the Æpyornithidæ; the length of this specimen is 63 mm. The upper end of the bone is modified in a manner similar to that seen in *Aptornis*, the head being placed very obliquely, and the inner trochanter (*tuberculum mediale*, *t.m.*), which is extremely prominent, rising above it; the pectoral crest (*cr.l.*) is reduced to a slightly projecting rugose surface. The lower end is somewhat similar to that of the humerus of *Casuarius*, but is still further reduced, the radial and ulnar trochleæ uniting completely to form a single articular surface. The nature of the specimen shown in fig. C (p. 386) is more doubtful, yet it so closely resembles the last in the form of its lower portion that I am led to believe that it is an avian humerus also; its upper end is, however, very different and peculiar. The head is large and nearly globular; it rises above the massive inner trochanter (*tuberculum mediale*), and is separated from it by a well-marked groove (*incisura collaris*). Here, also, the pectoral crest is reduced to a mere rugose prominence. If these two bones are in fact humeri of species of the Æpyornithidæ, they probably belong to different genera, a question which it is to be hoped will be settled by the discovery of complete skeletons of these interesting birds.

EXPLANATION OF THE PLATES.

Plate VIII.

Skull and Mandible of Æpyornis.

Fig. 1. Cranium from above.
2. Cranium from behind.
3. Cranium from side.
4. Premaxillæ.
5. Imperfect mandible from above.



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SKULL AND MANDIBLE OF ÆPYORNIS.

Fig 1.

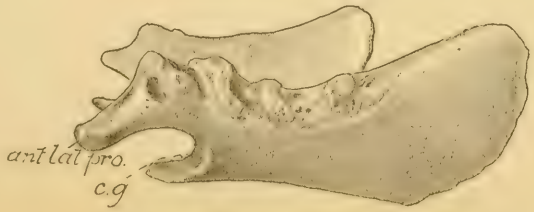

Fig. 2.

Fig. 6. Posterior view of angular region of mandible.
(The above figures are one half natural size.)
7. Diagram showing the structure of articular facet for quadrate.
8. Diagram showing arrangement of foramina in orbit.

Lettering for all the Figures.

car.for.	carotid foramen.
e.o.	exoccipital.
i.a.p.	internal angular process.
inf.a.p.	inferior angular process.
m.t.	mamillar tuberosity.
p.a.p.	posterior angular process.
p.orb.pr.	postorbital process.
p.c.f.	precondylar fossa.
par.oc.	paroccipital process.
post.t.f.	posterior temporal fossa.
post.t.r.	post-temporal ridge.
pr.	pro-otic.
sq.	squamosal.
t.f.	temporal fossa.
zyg.	zygomatic process.

The Roman numerals in fig. 8 refer to the numbers of the cranial nerves which pass through the foramina indicated.

PLATE IX.

Sternum of Æpyornis.

Fig. 1 from below; Fig. 2 from side. ($\frac{1}{2}$ nat. size.)

ant.lat.pro.	antero-lateral process.
post.lat.pro.	postero-lateral process.
c.g.	coracoid groove.
s.	trace of suture between the two halves of the sternum.

XXXV.—*Proceedings at the Annual Meeting of the British Ornithologists' Union, held April 22nd,* 1896.

THE Annual General Meeting of the British Ornithologists' Union was held at the rooms of the Zoological Society of London, 3 Hanover Square (by permission of the Council of that Society), on Wednesday, the 22nd of April, at 6 P.M. In the absence of the President, Mr. P. L. SCLATER, M.A., Ph.D., F.R.S., was requested to take the Chair. The Minutes of the last Annual Meeting having been read and confirmed, the Report of the Committee was read.